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FRESH PRODUCE STORAGE

This correspondence aid presents brief summaries in Tables 1 and 2 of the average storage requirements of fresh fruits and vegetables. The conditions given should not be considered absolute or final but rather as the safe limitations under which the various products can ordinarily be stored.

The temperatures recommended are the optimum for long storage. For short storage, higher temperatures may be satisfactory for some commodities. Conversely, products susceptible to chilling injury can sometimes be held at a temperature lower than indicated for several days without injury. Exceptions include bananas, cucumbers, eggplant, okra, pumpkins and squashes, sweetpotatoes, and mature green tomatoes. Recommended temperatures for these products should be strictly adhered to. Susceptibility to chilling is discussed in greater detail in the section on chilling injury.

Recommendations for the best conditions for storage of fresh fruits and vegetables may change from time to time as varieties and handling methods change and as more information is gained on storage requirements of these commodities.

Temperature

Refrigerated storage is recommended for many perishable commodities because it retards: (1) respiration and other metabolic activity; (2) aging caused by ripening, softening, and textural and color changes; (3) moisture loss and the resultant wilting; (4) spoilage caused by invasion by bacteria, fungi, and yeasts; and (5) undesirable growth, such as sprouting of potatoes. All temperature recommendations are given in degrees Fahrenheit.

If the best results are to be obtained in cold storage, the temperature in storage rooms must be held fairly constant. Variations of 2° or 3° F. above or below the desired temperature are too large in most cases. For example, most varieties of apples keep best and longest if held constantly at 30° to 32°; the best temperature for pears is between 29° and 30°. If the air temperature where either of these fruits is stored rises 2° or 3° above the upper limit mentioned or if the commodity is not cooled promptly to these temperatures, there is danger of increased decay and undue ripening. The danger is greater the longer the period during which the temperature is above the optimum.

For example, 3 or 4 days at 35° usually would have little or no effect, partly because of a slower rise in the temperature of the fruit than in that of the air; but 10 days at this temperature would probably shorten the life of the fruit by about a week and possibly result in more decay. On the other hand, if the temperature goes 1° or 2° below 29°, in a pear storage there is a chance that freezing will occur.

Celery and cabbage allowed to remain too warm in storage will show yellowing and decay; potatoes are likely to begin to sprout if the temperature is too high and to become

[1]Information supplied by Robert E. Hardenburg, Northeastern Region.

undesirably sweet if it is too low. Other commodities undergo these or other kinds of deterioration if the temperature variations throughout long storage periods exceed the limits given for them in the tables. In addition, fluctuations in temperature often cause condensation of moisture on stored products, which is undesirable because it may favor the growth of mold and the development of decay.

Maintaining uniform temperatures in all parts of a storage room is more important than avoiding small fluctuations at a given point. Fruit stored in a part of the room where the temperature is continuously higher than in another part ripens faster than that stored in the cooler part. This frequently results in mixing of overripe and prime fruit on removal, or it may result in undetected deterioration and decay in inaccessible locations.

Temperature variations can usually be prevented if the storage rooms are well insulated throughout and have adequate refrigeration and if the spread between the temperature of the refrigerant and that of the room to be refrigerated is kept small. Proper stacking and adequate air circulation also help to minimize temperature variation. Storage rooms should be equipped either with reliable, accurate thermostats or with manual controls that are given frequent personal attention by someone charged with that duty. Even when reliable automatic controls are used, they should be checked periodically.

In commercial cold-storage rooms, thermometers are usually placed at a height of about 5 feet for convenience in reading. It is important, however, to take temperatures frequently at the floor and the ceiling levels and at any other places where they might be expected to be undesirably high or low. It would be shortsighted to rely on just one or two aisle temperatures.

Product temperatures should be taken in packages or within bulk containers at various locations. A thermometer of good quality is essential; accurate temperatures cannot be expected from a poor one. Either a glass stem thermometer or a metal dial thermometer is recommended for taking temperatures of fresh produce. These should be checked occasionally to insure their accuracy. The test can be made by immersing a thermometer in and ice-and-water bath. Fill a pint-size container with chipped ice and then add water. Stir for 2 minutes and then immerse the thermometer for 2 minutes in the center of the mixture. Do no permit the thermometer bulb to rest against the side or bottom of the container. The thermometer should read with 1°, plus or minus, of 32° F.

Temperatures in less accessible locations, such as the middle of stacks, can be obtained conveniently with distant-reading thermometer equipment, such as thermocouples or electrical resistance thermometers.

Relative Humidity

The relative humidity of the air in storage rooms directly affects the keeping quality of produce. If it is too low, wilting or shriveling is likely to occur; if it is too high, it may favor the development of decay. Maintaining relative humidity high enough is usually a much greater problem than too high humidity in storages. High relative humidities of 90 to 95 percent are recommended for most perishable horticultural products, to retard softening and wilting from moisture loss. A few exceptions are shown in the tables.

Of major importance in maintaining adequate relative humidity in the storage air is providing good insulation, avoiding leaks, and providing sufficient cooling surface so that the spread between the temperature of the refrigerating surface and the desired commodity temperature is as small as possible, often only 1° to 2° F. Relative humidity may be checked with a sling or fan-operated psychrometer or with various types of hygrometers.

Chilling Injury

Certain fruits and vegetables are injured by low (32° to 50° F.) but nonfreezing temperatures. At these temperatures they become weakened because they are unable to carry on normal metabolic processes. Often products that are chilled look sound when removed from low temperatures, however, symptoms of chilling, such as pitting or other skin blemishes, internal discoloration, or failure to ripen, become evident in a few days at warmer temperatures. Susceptible fruits and vege-

tables that have been chilled may be particularly susceptible to decay. Alternaria rot is often severe on tomatoes, squash, peppers, and cantaloups that have been chilled.

Both time and temperature are involved in chilling injury. Damage may occur in a short time if temperatures are considerably below the danger line, but a product may be able to withstand a few degrees in the danger zone for a longer time. However, with some products such as grapefruit and cucumbers, injury may become apparent sooner at temperatures only slightly below the optimum than at lower temperatures. The effects of chilling are cumulative. Low temperatures in transit, or even in the field shortly before harvest, add to the total effects of chilling that might occur in storage.

Freezing Injury

The temperature usually recommended for storing fresh commodities are shown in tables 1 and 2. The highest temperatures at which freezing may occur also is shown. Always avoid subjecting fresh produce to freezing temperatures. Tissues injured by freezing generally appear water soaked and may be especially subject to decay.

Different commodities vary widely in their susceptibility to freezing injury. Some may be frozen and thawed a number of times with little or no injury while others are permanently injured by even slight freezing. The freezing point of the commodity is no indication of the damage to be expected by freezing or chilling.

For example, tomatoes and parsnips both have freezing points of 30° to 31° F., but parsnips can be frozen and thawed several times without apparent injury while tomatoes are ruined after one freezing. As with chilling injury, severity of freezing injury is influenced by a combination of time and temperature. Apples that would be injured little by exposure for a few days at temperatures slightly below the freezing point would be severaly injured by just a few hours' exposure to 15° to 20° F.

Table 1.—Recommended temperature and relative humidity, approximate storage life, and highest freezing point of fresh fruits in commercial storage

Commodity	Storage temperature	Relative humidity	Approximate length of storage period	Highest freezing point
	°F.	*Percent*		°F.
Apples[1]	30 to 40	90	3 to 8 months	29.3
Apricots	31 to 32	90	1 to 2 weeks	30.1
Avocados[1]	40 to 55	85 to 90	2 to 4 weeks	31.5
Bananas	56 to 58	90 to 95	Variable	30.6
Berries				
Blackberries	31 to 32	90 to 95	2 to 3 days	30.5
Blueberries	31 to 32	90 to 95	2 weeks	29.7
Cranberries	36 to 40	90 to 95	2 to 4 months	30.4
Currants	31 to 32	90 to 95	1 to 2 weeks	30.2
Dewberries	31 to 32	90 to 95	2 to 3 days	29.7
Elderberries	31 to 32	90 to 95	1 to 2 weeks	---
Gooseberries	31 to 32	90 to 95	2 to 4 weeks	30.0
Loganberries	31 to 32	90 to 95	2 to 3 days	29.7
Raspberries	31 to 32	90 to 95	2 to 3 days	30.0
Strawberries	32	90 to 95	5 to 7 days	30.6
Cherries, sour	32	90 to 95	3 to 7 days	39.0
Cherries, sweet	30 to 31	90 to 95	2 to 3 weeks	28.8
Coconuts	32 to 35	80 to 85	1 to 2 months	30.4
Dates	0 to 32	75	6 to 12 months	3.7
Figs, fresh	31 to 32	85 to 90	7 to 10 days	27.6
Grapefruit, California and Arizona	58 to 60	85 to 90	4 to 6 weeks	---
Grapefruit, Florida and Texas	50	85 to 90	4 to 6 weeks	30.0
Grapes, Vinifera	30 to 31	90 to 95	3 to 6 months	28.1
Grapes, American	31 to 32	85	2 to 8 weeks	29.7
Guavas	45 to 50	90	2 to 3 weeks	---
Lemons	38 to 55	85 to 90	1 to 4 months	29.4
Limes	48 to 50	85 to 90	6 to 8 weeks	29.1
Lychees	35	90 to 95	3 to 5 weeks	---
Mangos	55	85 to 90	2 to 3 weeks	30.3
Nectarines	31 to 32	90	2 to 4 weeks	30.4
Olives, fresh	45 to 50	85 to 90	4 to 6 weeks	29.4
Oranges, California and Arizona	38 to 48	85 to 90	3 to 8 weeks	29.7
Oranges, Florida and Texas	32	90 to 95	8 to 12 weeks	30.6
Papayas	45	85 to 90	1 to 3 weeks	30.4
Peaches	31 to 32	90	2 to 4 weeks	30.3
Pears	29 to 31	90 to 95	2 to 7 months	29.2
Persimmons, Japanese	30	90	3 to 4 months	28.1
Pineapples[1]	45 to 55	85 to 90	2 to 4 weeks	30.0
Plums and prunes	31 to 32	90 to 95	2 to 4 weeks	30.5
Pomegranates	32	90	2 to 4 weeks	26.6
Quinces	31 to 32	90	2 to 3 months	28.4
Tangerines, temple oranges, and related fruits	32 to 38	85 to 90	2 to 4 weeks	30.1

[1]The optimum storage temperature depends on the variety.

Table 2.—Recommended temperature and relative humidity, approximate storage life, and highest freezing point for fresh vegetables in commercial storage

Commodity	Storage temperature	Relative humidity	Approximate length of storage period	Highest freezing point
	°F.	*Percent*		°F.
Artichokes, globe	32	90 to 95	1 month	29.9
Artichokes, Jerusalem	31 to 32	90 to 95	2 to 5 months	---
Asparagus	32 to 36	95	2 to 3 weeks	30.9
Beans, green or snap	40 to 45	90 to 95	7 to 10 days	30.7
Beans, lima	32 to 40	90 to 95	3 to 5 days	31.0
Beets, bunched	32	95	10 to 14 days	31.3
Beets, topped	32	95	3 to 5 months	30.3
Broccoli, sprouting	32	90 to 95	10 to 14 days	30.9
Brussels sprouts	32	90 to 95	3 to 5 weeks	30.5
Cabbage, early	32	95	3 to 6 weeks	30.4
Cabbage, late	32	95	3 to 4 months	30.4
Cabbage, Chinese	32	95	1 to 2 months	---
Carrots, mature, topped	32	95	4 to 5 months	29.5
Carrots, immature, topped	32	95	4 to 6 weeks	29.5
Cauliflower	32	90 to 95	2 to 4 weeks	30.6
Celeriac	32	95	3 to 4 months	30.3
Celery	32	90 to 95	1 to 2 months	31.1
Collards	32	95	10 to 14 days	30.6
Corn, Sweet	32	90 to 95	4 to 8 days	30.9
Cucumbers	45 to 50	90 to 95	10 to 14 days	31.1
Eggplants	45 to 50	90 to 95	7 to 10 days	30.6
Endive and escarole	32	95	2 to 3 weeks	31.9
Garlic, dry	32	65 to 70	6 to 7 months	30.5
Ginger rhizomes	55	65	6 months	---
Greens, leafy	32	95	10 to 14 days	---
Horseradish	30 to 32	95	10 to 12 months	28.7
Kale	32	95	2 to 4 weeks	31.1
Kohlrabi	32	95	2 to 4 weeks	30.2
Leeks, green	32	95	1 to 3 months	30.7
Lettuce	32	95	2 to 3 weeks	31.7
Melons				
Cantaloup (3/4-slip)	36 to 40	85 to 90	15 days	29.9
Cantaloup (full slip)	32 to 35	85 to 90	5 to 14 days	29.9
Casaba	45 to 50	85 to 90	4 to 6 weeks	30.1
Crenshaw	45 to 50	85 to 90	2 weeks	30.1
Honeydew	45 to 50	85 to 90	3 to 4 weeks	30.3
Persian	45 to 50	85 to 90	2 weeks	30.5
Watermelon	40 to 50	80 to 85	2 to 3 weeks	31.3
Mushrooms	32	90	3 to 4 days	30.4
Okra	45 to 50	90 to 95	7 to 10 days	28.7
Onions, dry, and onion sets	32	65 to 70	1 to 8 months	30.6
Onions, green	32	95	3 to 4 weeks	30.4
Parsley	32	95	1 to 2 months	30.0
Parsnips	32	95	2 to 6 months	30.4
Peas, green	32	90 to 95	1 to 3 weeks	30.9
Peppers, chili, dry	32 to 50	60 to 70	6 months	---
Peppers, sweet	45 to 50	90 to 95	2 to 3 weeks	30.7

Continued—

Table 2.—Recommended temperature and relative humidity, approximate storage life, and highest freezing point for fresh vegetables in commercial storage—continued

Commodity	Storage temperature	Relative humidity	Approximate length of storage period	Highest freezing point
	°F.	*Percent*		°F.
Potatoes, early-crop[1]	40 to 50	90	2 to 4 months	30.9
Potatoes, late-crop[1]	38 to 40	90	5 to 8 months	30.9
Pumpkins	50 to 55	70 to 75	2 to 3 months	30.5
Radishes, spring	32	90 to 95	3 to 4 weeks	30.7
Radishes, winter	32	90 to 95	2 to 4 months	---
Rhubarb	32	95	2 to 4 weeks	30.3
Rutabagas	32	98 to 100	4 to 6 months	30.1
Salsify	32	95	2 to 4 months	30.0
Spinach	32	95	10 to 14 days	31.5
Squashes, winter	50 to 55	50 to 75	--------	30.5
Squashes, summer	32 to 50	90	5 to 14 days	31.1
Sweetpotatoes	55 to 60	85 to 90	4 to 7 months	29.7
Tomatoes, mature, green	55 to 70	85 to 90	1 to 3 weeks	31.0
Tomatoes, firm, ripe	45 to 50	85 to 90	4 to 7 days	31.1
Turnips	32	95	4 to 5 months	30.1
Turnip greens	32	95	10 to 14 days	31.7
Watercress	32 to 35	95	3 to 4 days	31.4

[1]Potatoes for processing have special storage requirements.